

## SYSTEM AND METHOD FOR ARRAY PROCESSING OF SURFACE ACOUSTIC WAVE DEVICES

### Cross-Reference to Related Application

This application claims priority to commonly owned provisional application Serial Number 60/209,692, filed June 6, 2000.

### Field of the Invention

The present invention relates generally to techniques for processing and encapsulating microelectronic components, and specifically relates to systems and methods for efficiently packaging surface acoustic wave devices.

### Background of the Invention

Surface acoustic wave (SAW) devices are used in a broad range of RF and IF applications, including wireless communication and cable television. Because the acoustic wave propagates at the surface of the piezoelectric die in SAW devices, the performance of the device can be affected by the environment to which the die is exposed. To avoid such exposure, it is desirable to seal SAW dies inside hermetic packages. In recent years, SAW packages have been fabricated from ceramic and hermetically sealed with metal or ceramic lids using seam welding, solder reflow, or glass frit sealing techniques.

Recent advances in SAW technology, particularly for applications in wireless communications, require smaller SAW devices. While a few years ago it was common for SAW filters used in mobile phone handsets to exceed 12 millimeters in length, such devices are now (in many cases) only a few millimeters long. This miniaturization of SAW filters is likely to continue for some time.

With moderate to large packages, manufacturing using singulated packages that are mechanically fixtured in carriers is feasible. The processes of die attach, wire bond, and lid attachment can all be automated using conventional techniques. As package size shrinks, however, the fixturing and handling of singulated packages and lids becomes more difficult and inefficient. To enhance the manufacturability of such small packages, SAW device manufacturers are developing techniques for processing SAW packages in monolithic ceramic arrays that contain many (often 300

or more) packages per array. The array serves as a base for die attach and formation of electrical connections to the die (whether through wire bonding, flip chip, or other techniques). While the techniques for attaching and interconnecting SAW die to arrays are well understood, the methods for attaching lids to these arrays are very limited.

It would appear from the construction of prior art devices that some SAW manufacturers are using cupped ceramic lids attached to the SAW packages using an insulating resin (B-staged epoxy, by way of example). One can manufacture such devices by aligning and placing the cupped ceramic lids over each die on a heated array. The seal surface of the lids is coated with the B-staged epoxy prior to assembly on the array. The array is designed with a clearance between the lids for subsequent singulation operations. The use of a B-staged epoxy allows the lids to be placed in close proximity to each other without the need for physical barriers or aligners between consecutive lids. The tacky, viscous nature of the heated, B-staged epoxy holds the lids in place prior to final cure and helps prevent the resin from wicking between consecutive lids. Unfortunately, such resin sealing techniques are inherently non-hermetic and allow certain gases (especially water vapor) to permeate through the package seal.

Typically, hermetically sealed SAW filter packages are usually fabricated with a solder sealed flat metal lid. Unfortunately, there currently are no effective methods for placing and fixturing small solder lids onto arrays prior to and during reflow. SAW device manufacturers utilizing solder sealing techniques are doing so with discrete, singulated packages and lids. In most cases, the solder lids are externally fixtured onto the singulated packages and reflowed in inert atmosphere ovens without the use of solder flux. The tacky nature of solder flux is often used to help hold electronic components in place during reflow. However, SAW devices are extremely sensitive to foreign materials on the surface of the electrodes. The residue from the flux can become trapped in the sealed package after reflow and can deposit on the active surface of the SAW die.

In contrast to singulated package solder sealing, the technique of externally fixturing solder lids onto an array is very difficult to accomplish due to the small dimensions of the lids, the limited clearance between packages on the array, and the

camber of the array. In addition, it is difficult to maintain integrity between the external fixture and the array during reflow. The external fixture must be aligned precisely and held in intimate contact with the entire array during the reflow process in order to effectively isolate the thin lids and prevent the solder from bridging between lids. The present invention alleviates all of the difficulties associated with lid fixturing and package sealing encountered in the current art.

### Summary of the Invention

The present invention is directed to a system and method permitting array processing of surface acoustic wave devices and other microelectronic components.

The preferred method of the present invention comprises the steps of (a) forming a unitary array of a nonconductive material having opposing first and second surfaces and plural spaced cavities extending into the array from the first surface, each cavity dimensioned to receive a SAW device therein; (b) forming a recess at each cavity adjacent the first surface, each recess having a width greater than the corresponding cavity and dimensioned to receive a lid within the recess; (c) providing at least two conductive paths from the interior of each cavity to a surface of the array; (d) inserting a SAW device into each of a plurality of the cavities, each SAW device having conductive means electrically contacting the conductive paths within the interior of the corresponding cavity after insertion; (e) sealing a lid in the recess over each inserted SAW device; and then (f) separating the array into individual SAW devices along separation lines between adjacent cavities.

Another important aspect of the present invention is the ability to maintain spacing between adjacent cavities after the separating step. This may be achieved by applying tape means over the sealed lids and the first surface.

The present invention also comprises surface acoustic wave devices manufactured according to the methods described above. Those devices are formed from an assembly comprising the unitary array with cavities and recesses as described above, and with a SAW device inserted into each one of a plurality of the cavities in electrical contact with conductive paths extending from the interior of the corresponding cavity to a surface of the array. After the sealing of a lid in each

respective recess over the inserted SAW device, the array is separated into individual SAW devices.

It is an overall object of the present invention to provide a lid fixturing technique that, when integrated into the package, allows for the hermetic sealing of ceramic SAW packages in an array format while also providing adequate clearance between package sites for subsequent singulation. The packages are preferably sealed with solder although other sealants may be used. The walls of the recess contain the lids during handling and prevent solder from bridging between lids during reflow. Suitably, the recess is the same thickness as the lids. Preferably, the recess is an integral part of the package and provides a ceramic "picture frame" on top of a package layout. As a result, the lids can be placed precisely onto each package site with an off-line, automated placement machine and without the need for an external fixturing apparatus.

In order to seal the lids, a matrix of free-floating weights or a flat plate is placed on top of the lids in the array and the assembly is placed in an inert atmosphere oven for subsequent reflow. The inherent fixturing capabilities of the "picture-frame" recesses, in conjunction with a slightly expanded array layout, allows for the solder sealing of small footprint, multilayer ceramic SAW packages in an array format, while providing adequate clearance between package sites for subsequent singulation by dicing between adjacent cavities.

The solder sealing technique may use solder coated, solder clad, and solder preform metal or ceramic lids. While solder sealing is the sealing method of choice, resin sealing and glass frit sealing may also be used. The sealing media (resin, glass, or solder) may be an integral part of the lid, an integral part of the package array, or applied to the package or lid prior to assembly.

#### **Brief Description of the Drawings**

FIG. 1 is a perspective view, partially cut away, of a portion of an assembly used in the method of the present invention.

FIG. 2 is a perspective illustration of a typical ball bonding of flip chip surface acoustic wave (SAW) device.

FIG. 3 is a cross-sectional view of a portion of the assembly of the present invention, at a point following separation of the array into individual SAW devices along separation lines, and while spacing between individual arrays is being maintained.

FIG. 4 is a perspective illustration of an encapsulated surface acoustic wave device in accordance with the present invention.

FIGS. 5 and 6 are bottom and side views, respectively, of a first solder configuration for lids useful with the assembly of the present invention.

FIGS. 7 and 8 are bottom and side views, respectively, of a second solder embodiment for the lid of the present invention.

### **Detailed Description**

A system and method for array processing of surface acoustic wave devices in accordance with this invention will now be described with reference to FIGS. 1-4.

In FIG. 1, the assembly used in practicing the method is referred to generally with reference numeral **10**. The assembly **10** includes an array formed in a ceramic body **12** having an upper surface **14** and a lower surface **16**. The array includes plural cavities **18**, each extending into the ceramic body **12** from the upper surface **14** to a cavity bottom **20**. As thus configured, there is a small dimension of the ceramic body **12** between the cavity bottom **20** and the second surface **16** (note the cross-section of FIG. 3).

The assembly is provided with at least two conductive paths extending from the interior of each cavity **18** to a surface of the ceramic body **12**. As shown in FIGS. 1-4, these conductive paths are provided by conductive layers **22**, **24** on the bottom **20** of the cavity **18**, which are respectively electrically connected to conductive vias **30**, **34** extending through the ceramic body **12** and terminating in respective contact pads **32**, **36** along the second surface **16**. Conductive via **34** also extends into contact with an overlap area **28** and in contact with the lid solder **63**, as shown in FIG. 3 and described in greater detail below.

In accordance with the present invention, a lid alignment recess **26** is formed in the body **12** at each cavity **18** adjacent the first surface **14**, with each recess having a width and length which is greater than the corresponding cavity

**18** and being dimensioned to receive a lid **60** within the recess. The recess **26** thus defines an overlap area **28** which is in contact with solder **63** on the lower surface of the lid **16** after the lid is placed in the recess, as shown in FIG. 3.

Reference is now made to FIG. 2, which illustrates a typical surface acoustic wave (SAW) device **40** formed in a piezoelectric body **42** having an upper surface **44** onto which are deposited a first set of interdigitated electrodes **46** with associated bond pad **48** and a second set of interdigitated electrodes **50** with associated bond pad **52**. As shown in FIG. 3, during processing, the SAW device **40** is oriented in the cavity **18** with the bond pads **48**, **52** in respective contact with the conductive layers **22**, **24** in a typical "flip-chip" arrangement. It will of course be understood by one skilled in the art from the discussion set out below that the cross-section of FIG. 3 illustrates the assembly after bonding, so as to fix the SAW device **40** in place before the assembly **10** is inverted for separation of individual components and testing.

Referring again to FIG. 1, after the SAW device **40** is placed in the cavity **18** the lids **60** are then placed over the cavities **18** in the lid alignment recesses **26** and in contact with the overlap area **28**. Preferably, this is achieved using automated equipment.

Referring now to FIGS. 5-8, there is shown two different examples of suitable solder configurations for the lid **60**. In FIGS. 5 and 6, the solder joint **63** is restricted to the peripheral area of the bottom surface **64** and corresponds to the overlap area **28** (FIG. 1). In the arrangement shown in FIGS. 7 and 8, the solder joint **65** is applied as a continuous layer over the entire bottom surface **64** of the lid **60**. The embodiment of FIGS. 5 and 6 is depicted in the cross-sectional view of FIG. 3. During processing, the lids **60** are held firmly in place within the respective lid alignment recesses **26** using free-floating weights or a flat plate placed on top of the lids in the array, while being subjected to heat in an inert atmosphere in order to cause the solder joint **63** to flow.

After the reflow step discussed above, means are applied to the bottom surface **16** of the ceramic body **12** to maintain the integrity of the array during separation of individual SAW devices along separation lines **70**, **72**. In a preferred arrangement, this means comprises a tape **74** applied across the first surface **14**

and the top surface **62** of the lids **60**. Preferably, the array is "singulated" (i.e., rendered into individual components) via dicing SAW or another suitable separation technique along the separation lines **70, 72**. Thereafter, the tape **74** is removed to permit further handling of the individual SAW devices **100**.

As shown in FIG. 4, the resulting singulated SAW device **100** comprises a portion of the ceramic body **12** and its associated upper and lower surfaces **14, 16** and side surfaces **71, 73** which are formed from respective separation lines **70, 71**. The lid **60** is hermetically sealed within the lid alignment recess **26**. It will of course be appreciated by those skilled in the art that the SAW device **100** is capable of significant miniaturization relative to prior art devices.

This concludes a description of this invention. It will be apparent to those skilled in the art that various modifications can be made to these embodiments without departing from the spirit and scope of the present invention. For example, while a ceramic array has been described, other materials may be suitable as an array material. Further, as described above, resins and glass frit may be employed as suitable sealing materials. Likewise, other suitable arrangements may be employed to accomplish the objective of the alignment recess.